MODELING THE EFFECTS OF LAND USE CHANGES ON CALIFORNIA'S CLIMATE

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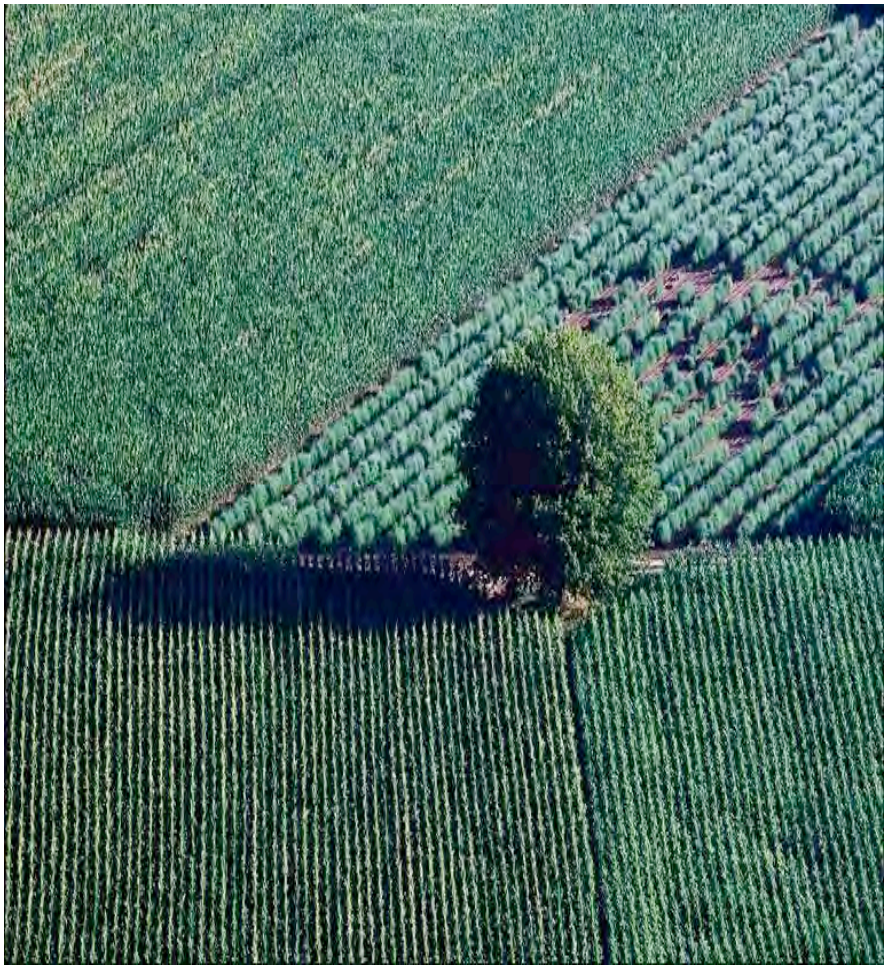
Land Use and Climate



- Numerous field and modeling studies have indicated that changes in land surface characteristics (land cover) can have large impacts upon climate, ***especially at regional scales***
- These climate impacts primarily take the form of changes in temperature

Land Use and Climate

- The land surface currently covered by pastures, agriculture and urban environments cover ~41% of the Earth's ice-free land surface
- In the western US, >79,000 km^2 have been converted to irrigated agriculture and urban areas

Salton Sea and Imperial Valley

Land Use and Climate

- Irrigation has been used to offset or overcome rainfall deficiencies on > 18 million acres in the western US

The California Energy Commission Regional Climate Model Intercomparison Project

- The primary goal of this study is to investigate the role that past land use changes may have had on California's climate, focusing upon the impacts of irrigation and urbanization
- This study utilizes four regional climate models (RCMs) with different characteristics and levels of development

The Regional Climate Models

- RSM - NOAH (Scripps)
- RegCM3-BATS (UCSC)
- MM5-CLM3 (LBNL)
- DRCM (UCD)
- The models vary in their description and parameterization of some climate processes. *Of paramount importance to this study is the differential treatment of irrigated cropland and urban land cover types in each model*

- Each RCM examined two cases: a modern land surface (~1992) and a pre-settlement, potential, natural vegetation land surface (pre-1850)
- All RCMs used land cover source data for these time intervals
- All RCMs used the same atmospheric driving data (10/1/95 - 9/30/96) at the lateral boundaries of a common model domain

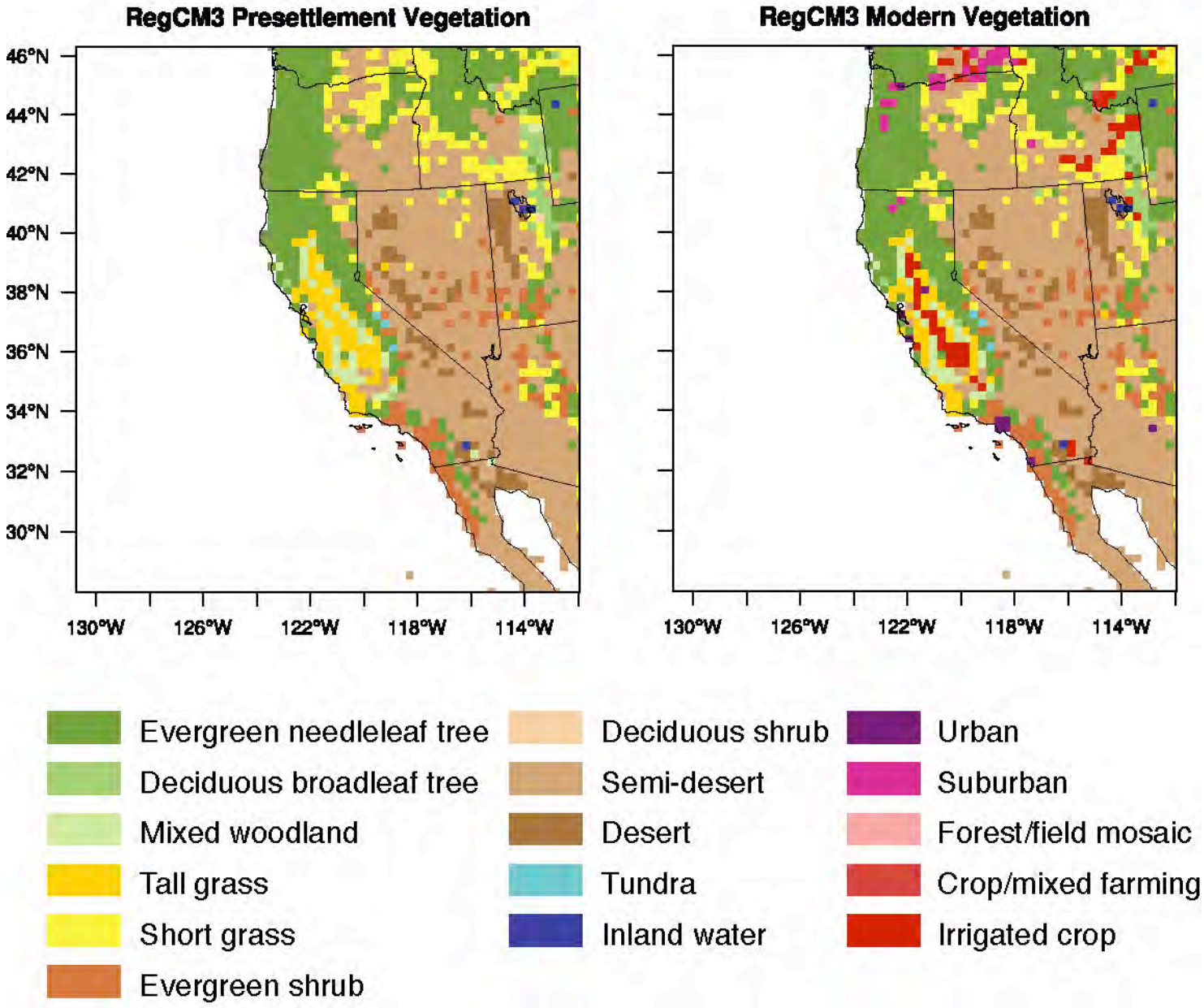
Model Treatment of Irrigated Cropland

- RSM forces irrigated cropland soil to be saturated
- RegCM3 forces irrigated cropland to be at field capacity (maximum water held by soil column against gravity)
- MM5-CLM3 does not specifically include irrigated cropland
- DRCM augments soil moisture when uppermost soil T $\geq$ 12C

Land Cover Distributions

- Each model was used to examine modern and pre-settlement climate as forced by land cover changes
- The different models began with the same land cover depiction
- Each model's land cover dataset was then modified to fit land cover categories in each land surface submodel
- The four models have different land cover types

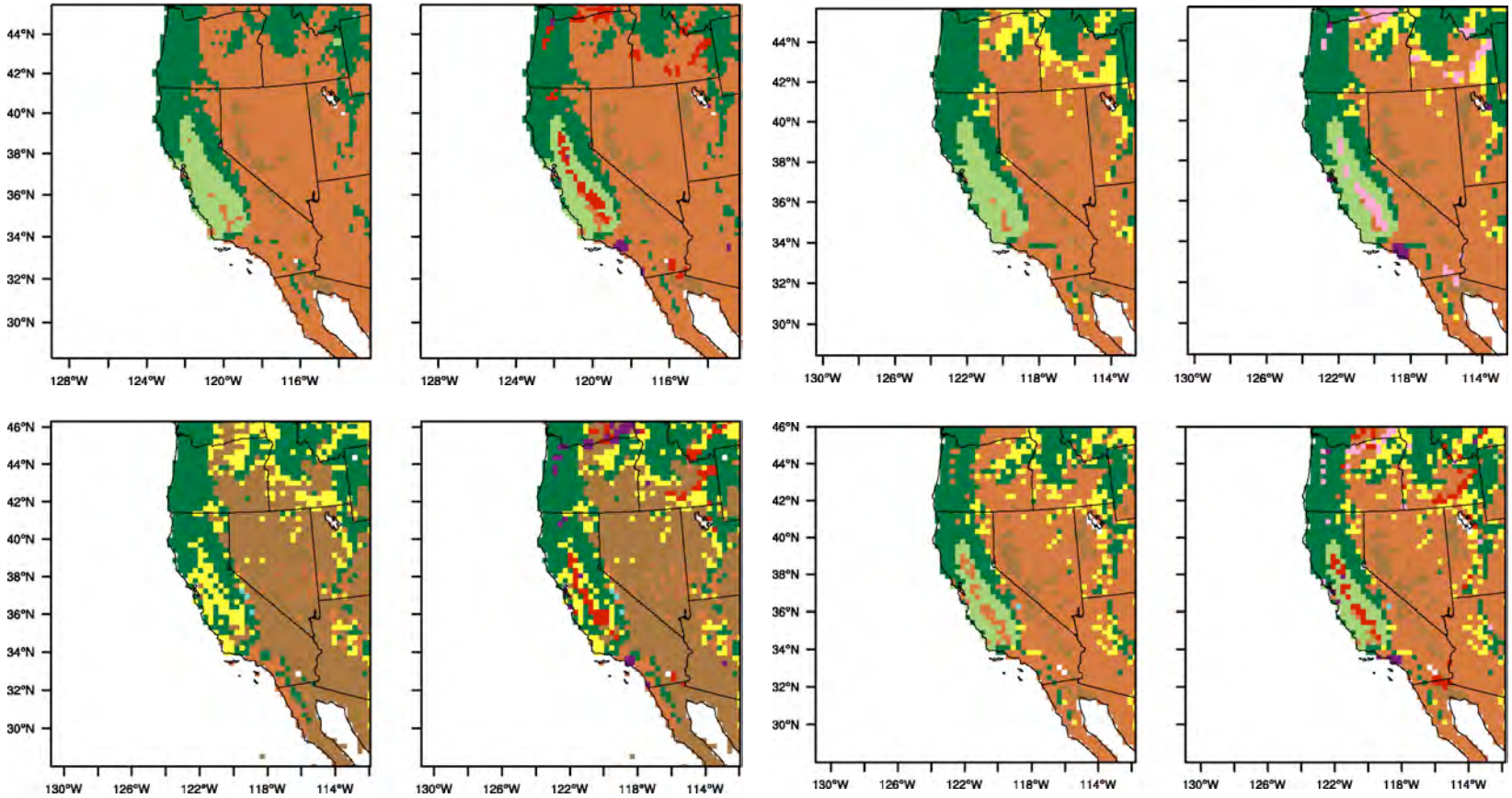
RegCM3 LAND COVER



Natural and Modern Land Cover

RSM

MM5

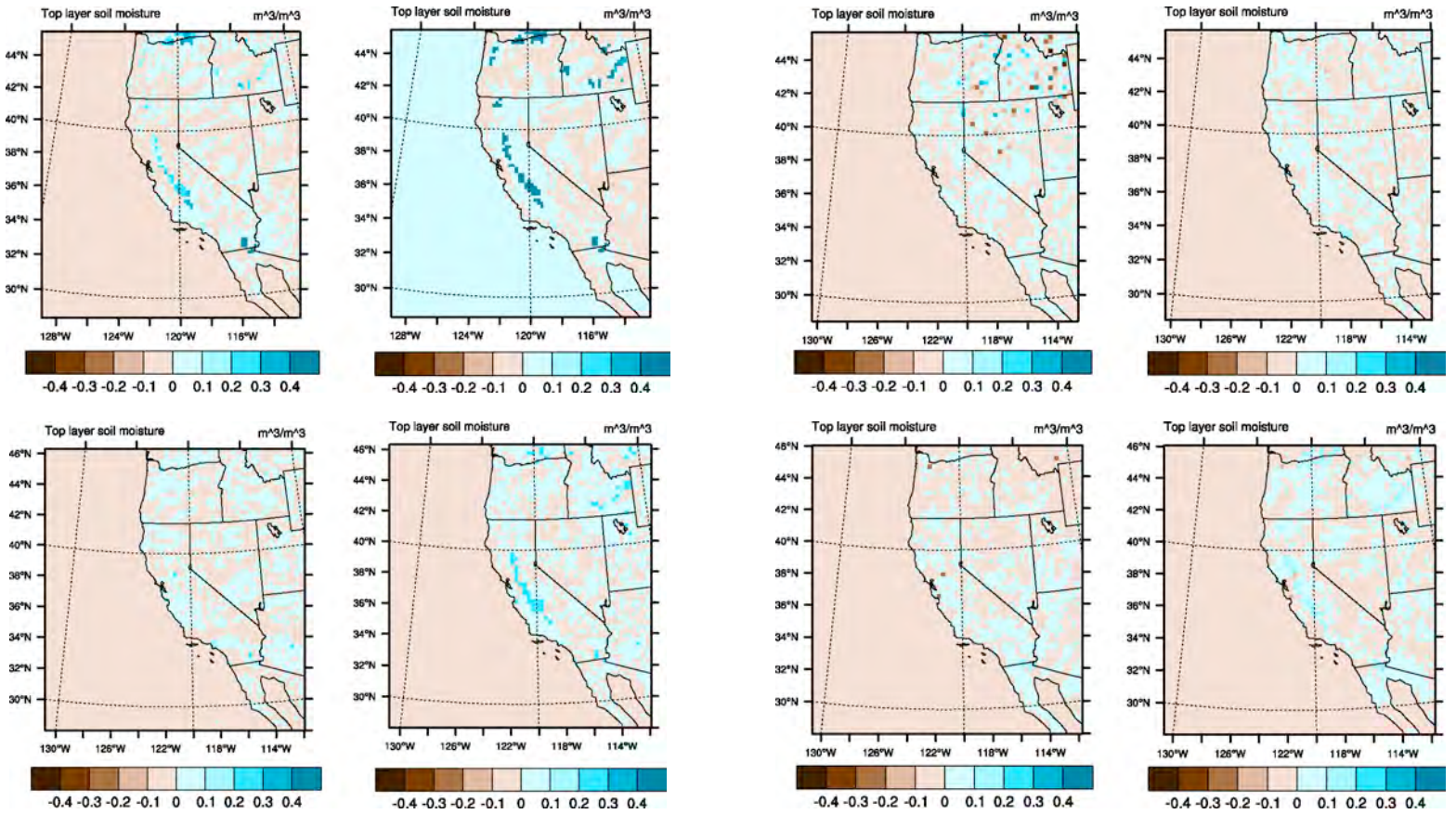


RegCM

DRCM

TOP LAYER SOIL MOISTURE, MODERN - NATURAL

RSM MM5

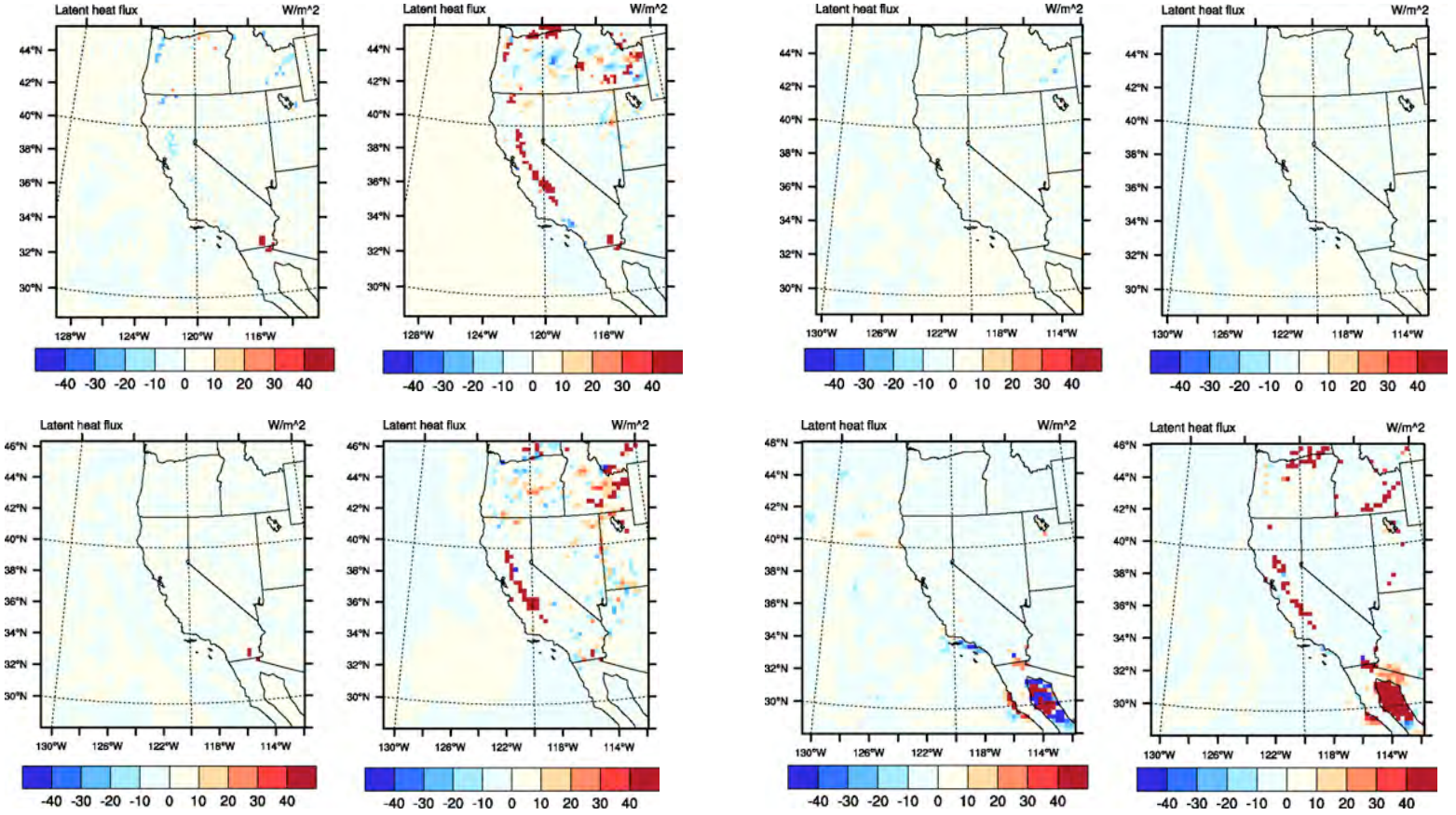


RegCM DRCM

LATENT HEAT FLUX (W/m^2), MODERN - NATURAL

RSM

MM5

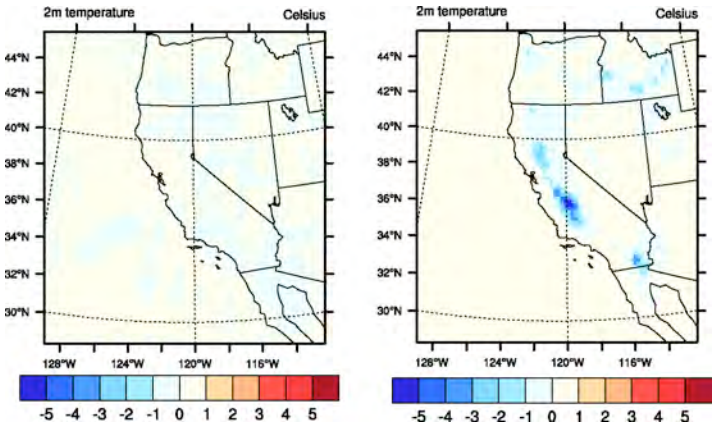


RegCM

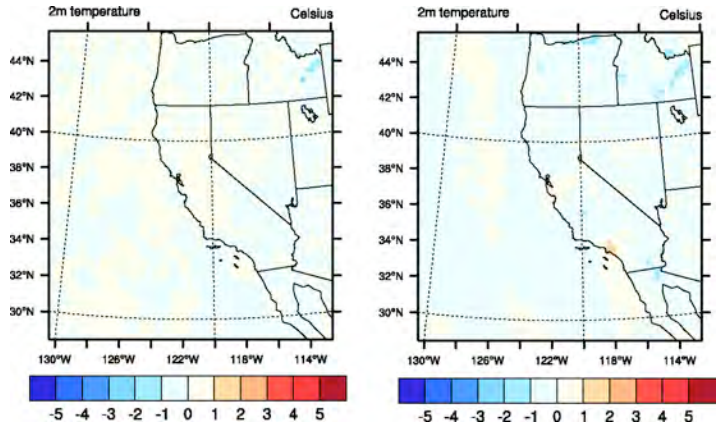
DRCM

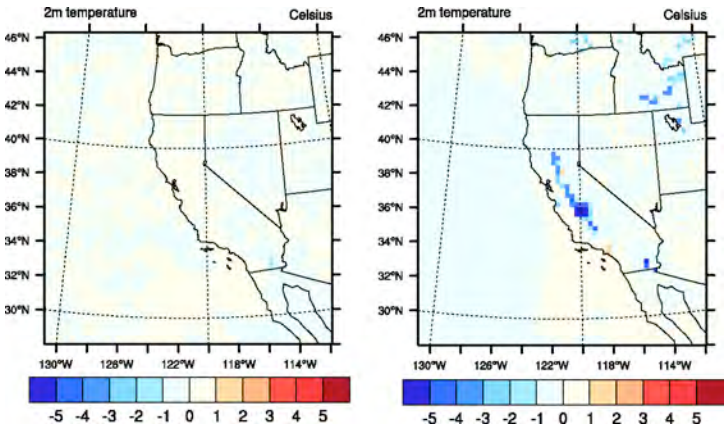
MEAN 2m TEMPERATURE, MODERN - NATURAL,

RSM

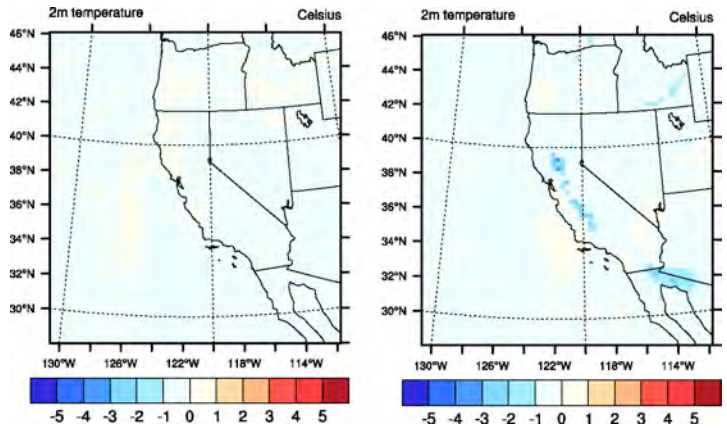


MM5





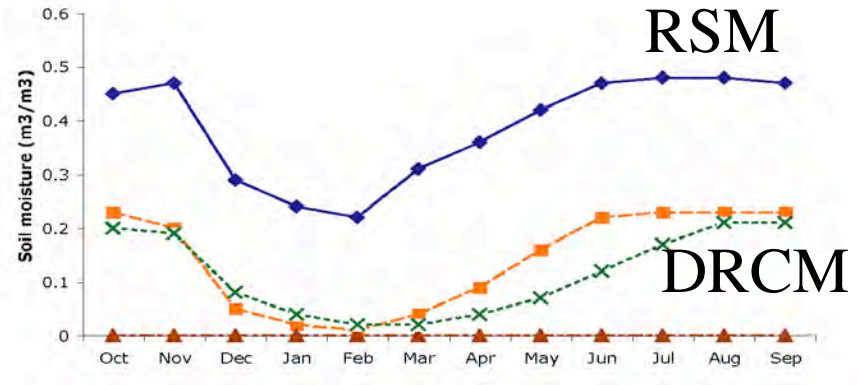
RegCM



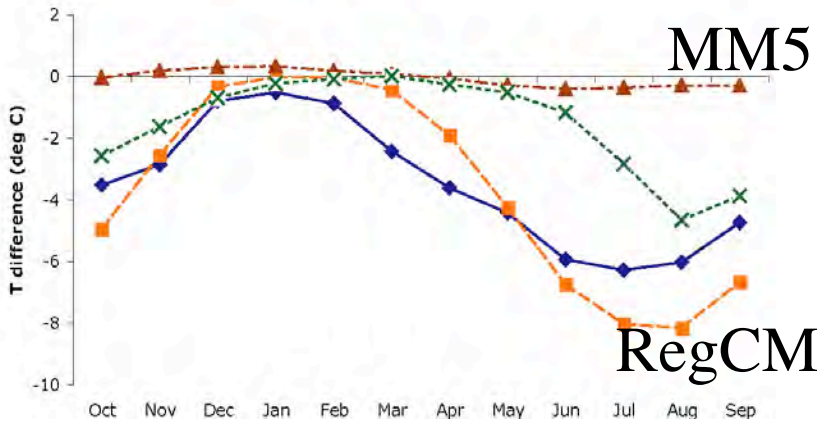
DRCM

Central Valley Irrigated Croplands Annual Cycle, MODERN - NATURAL

- Soil moisture variation varies proportionally with degree of irrigation forcing

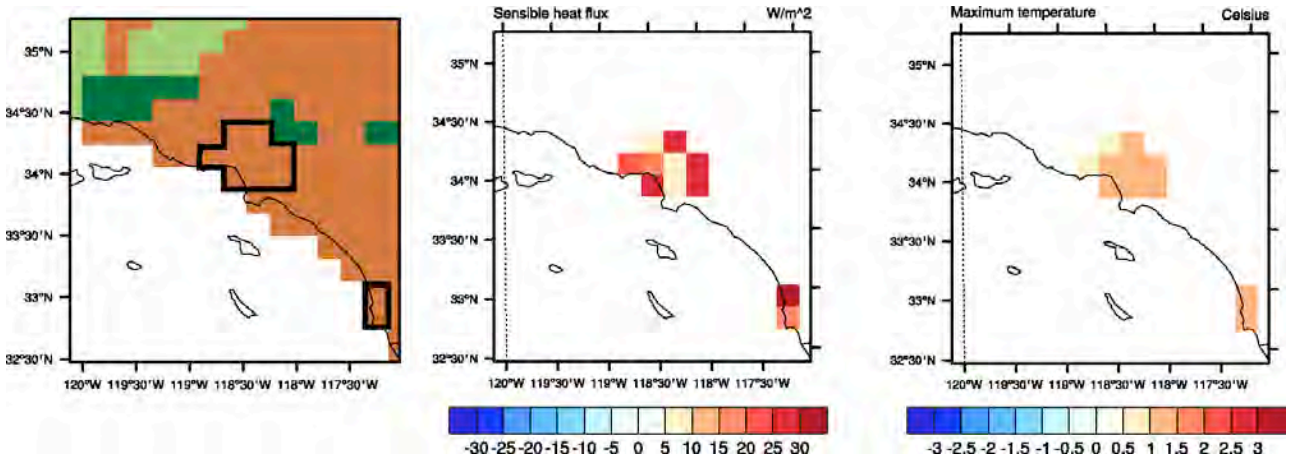


- Maximum 2m air temperature difference varies inversely with soil moisture and latent

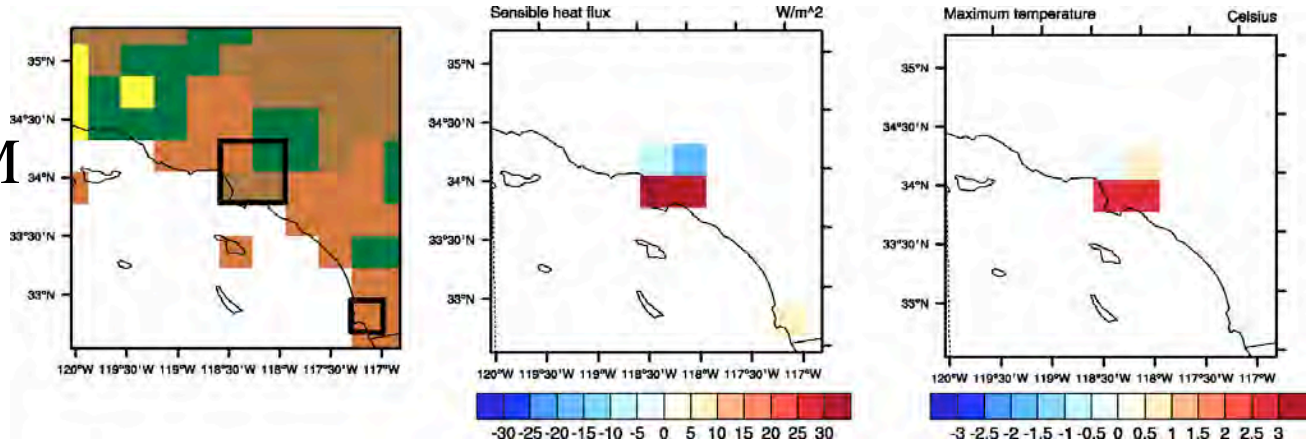


Los Angeles
Sensible Heat Flux, Maximum T
MODERN - NATURAL

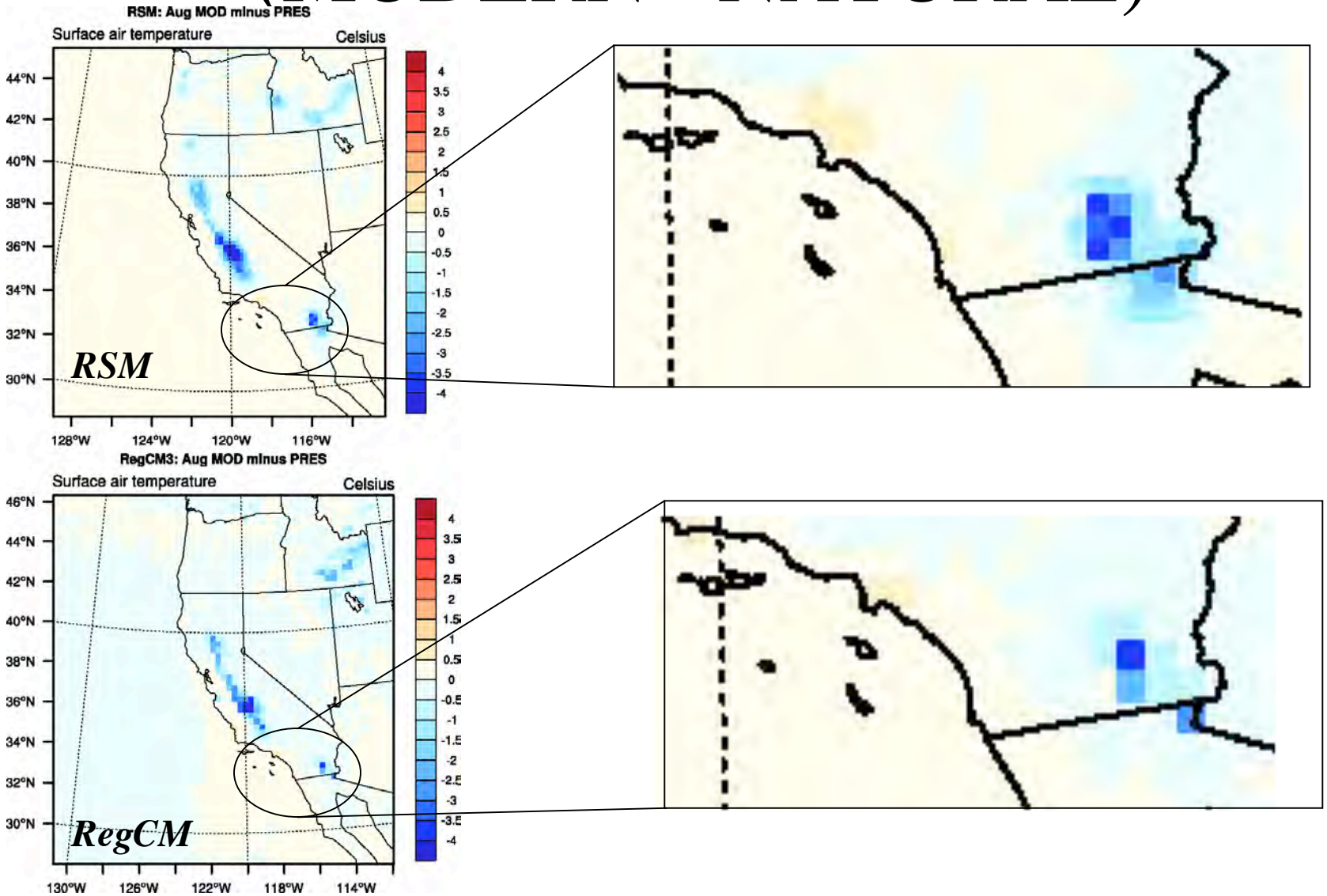
RSM



RegCM



Surface Air Temperature Difference (MODERN - NATURAL)



Results

- Some models show modest temperature increases in areas of urban land cover, largely due to decreased albedo, relative to the higher albedo of the natural land cover it replaced

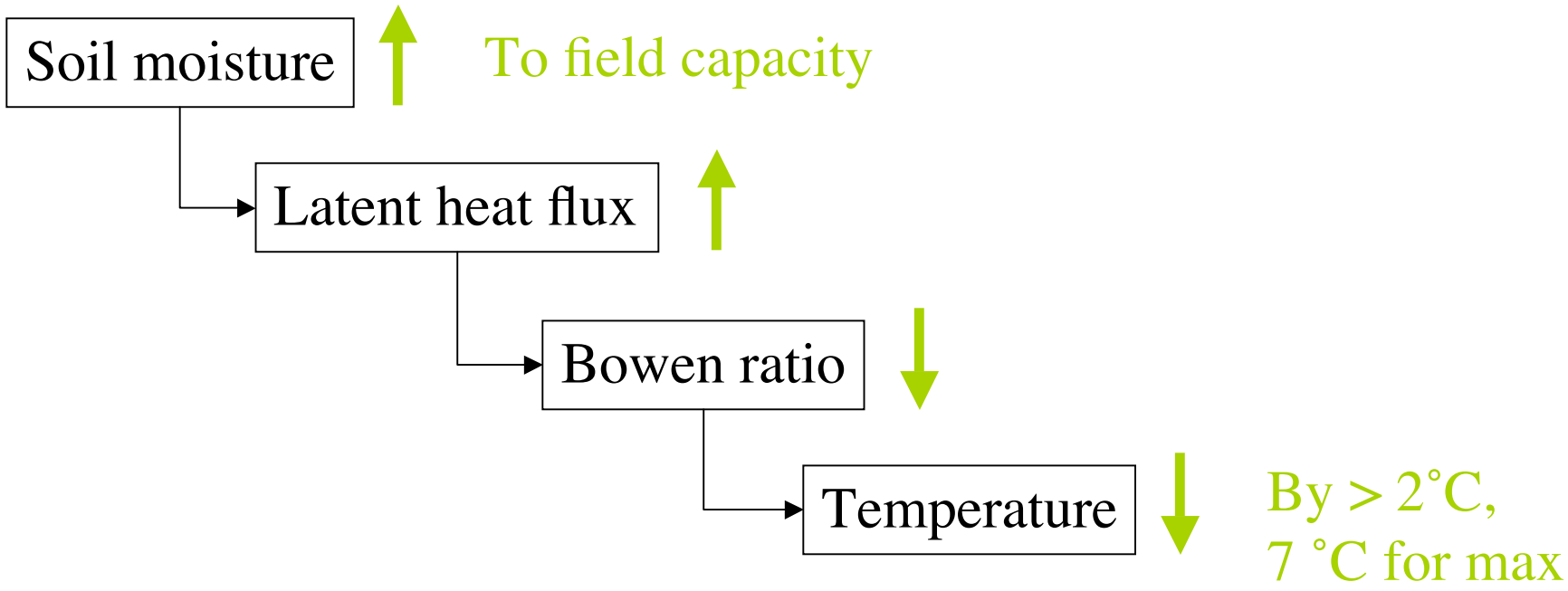
- Most models showed larger temperature decreases and increased relative humidity in areas of irrigated croplands, concentrated in the summer season

Results

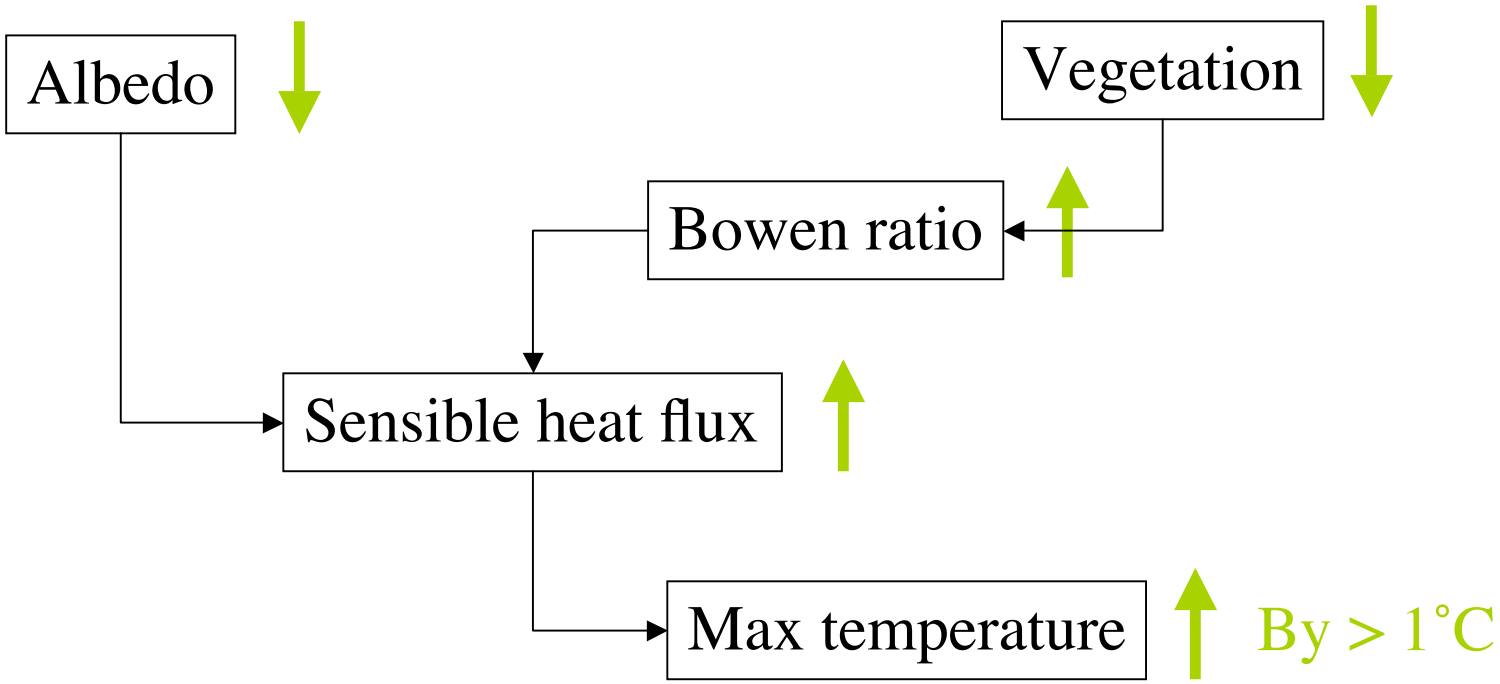
- The degree of cooling in irrigated cropland areas was proportional to the degree of soil moisture and associated evaporation, as determined by irrigated cropland parameterizations

- Importantly, the temperature change in response to the conversion to irrigated cropland is the ***same order of magnitude, but opposite in sign***, as some of the regional temperature changes that occur in response to increased greenhouse gas concentrations in RCM future scenarios

Summary: Irrigated Land



Summary: Urban Land



Acknowledgments

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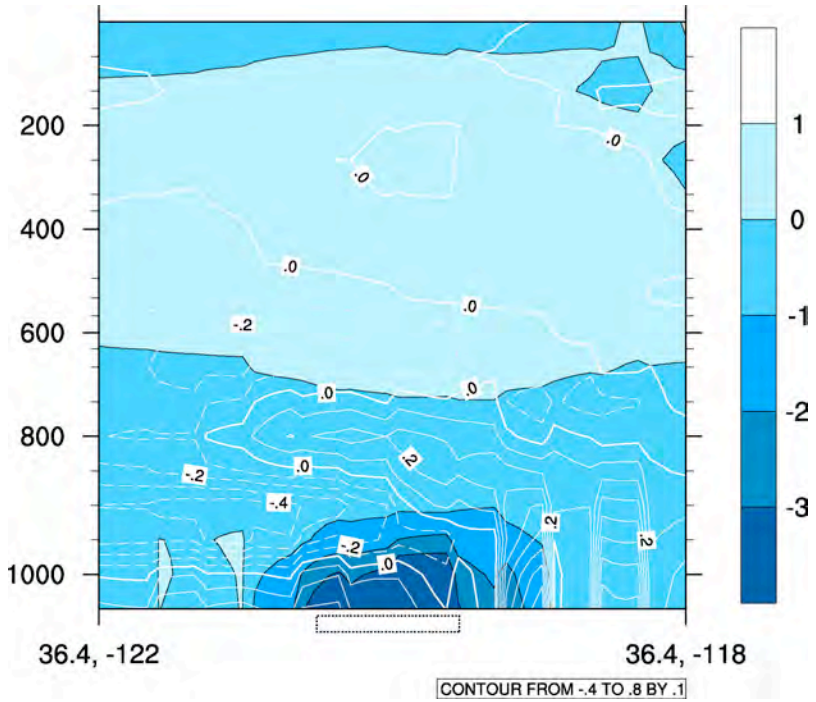
200
400
600
800
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1
0
-1
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36.4, -122
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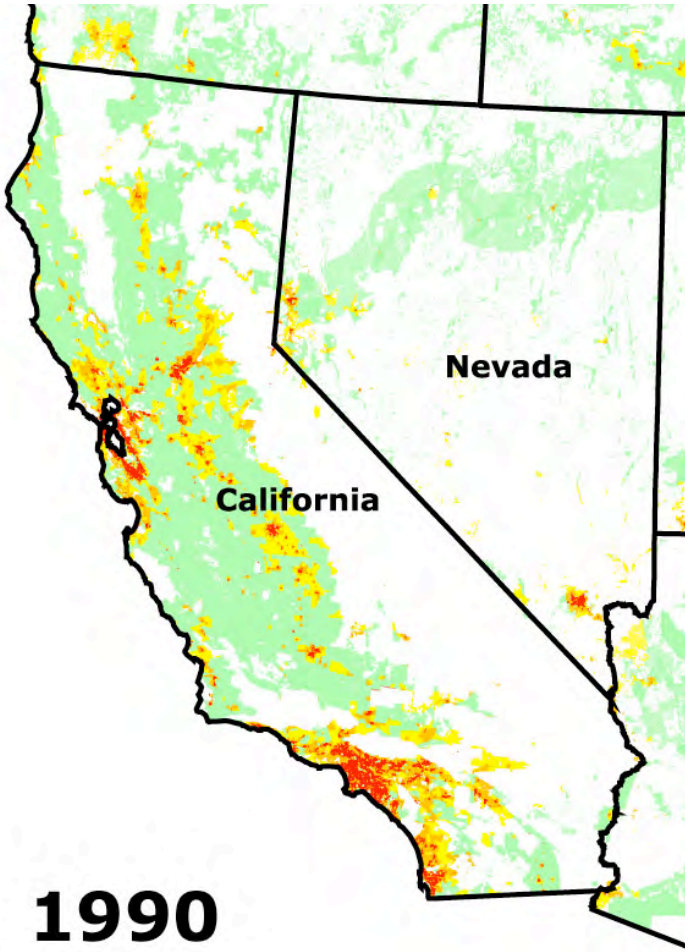
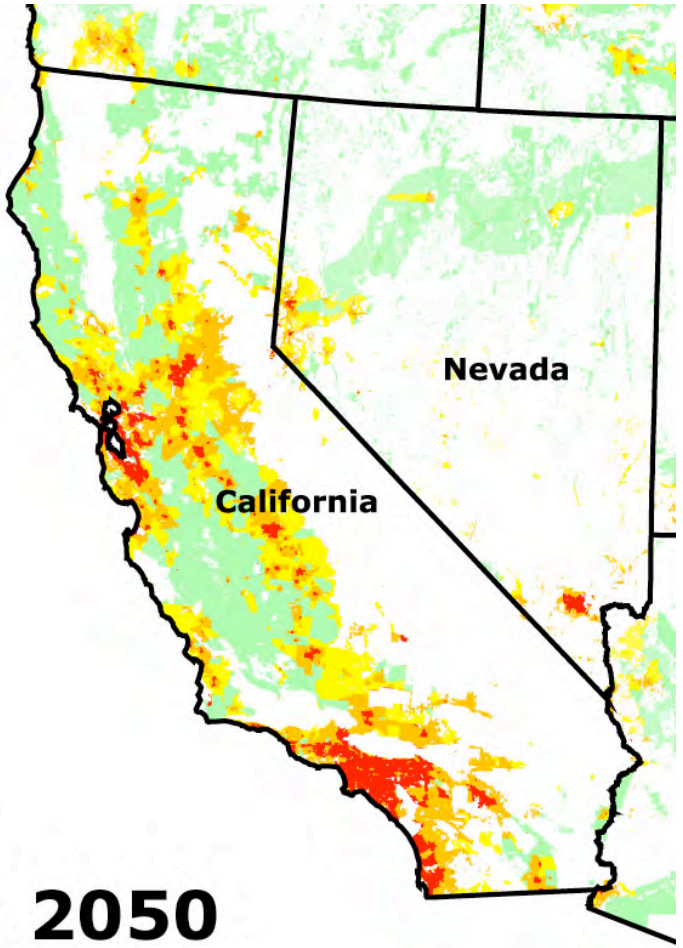
CONTOUR FROM -.4 TO .8 BY .1

Future (Sub)Urbanization





(Theobald, 2005 *Ecology and Society*)